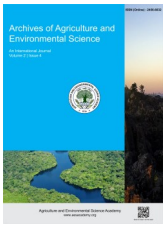
Archives of Agriculture and Environmental Science 11(2): 168-175 (2026)
https://doi.org/10.26832/24566632.2026.110203

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE

Smallholder farmers' perceptions of climate-smart practices in oilseed and pulse production: Evidence from Barguna district, Bangladesh

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ARTICLE HISTORY

Received: 12 February 2026
Revised received: 29 April 2026
Accepted: 11 May 2026

Keywords

Climate-Smart Practices
Oilseed and Pulse production
Perceptions
Smallholder

ABSTRACT

This study aimed to assess farmers' perceptions, adoption patterns, and constraints related to climate-smart agricultural (CSA) practices in oilseed and pulse production in Barguna district in Bangladesh. A mixed-methods research design was employed, integrating quantitative household surveys of 120 farmers selected through stratified random sampling. The results showed that mustard was the dominant oilseed crop by 75.83%, followed by sesame 45.00%, sunflower 37.50%, groundnut 31.67%, and soybean by 26.67%, while pulse cultivation remained limited, particularly grass pea by 10.83% and mung bean 20.00%. The study found that extreme climate events were reported by 78.33% of farmers, waterlogging by 77.50%, soil salinity by 66.67%, and limited extension access by 76.67%. Meanwhile, input constraints were reported by 53.33%, lack of quality seed by 67.50%, and credit limitations by 53.33%. Despite these challenges, farmers reported access to government support at 90.83%, short-duration varieties at 81.67%, and cooperative farming at 77.50%. Adoption of improved drainage systems was reported by 66.67% of farmers, and crop rotation by 54.17%, while adoption of integrated pest management at 23.33% and advanced climate-smart technologies at 28.33% remained low. Therefore, oilseeds and pulses offer strong potential for climate-resilient, diversified agriculture in coastal Bangladesh, adoption remains constrained by intersecting environmental, institutional, and knowledge barriers, necessitating integrated policy and extension interventions to bridge the gap between potential and practice.

Citation of this article: Islam, M. A., & Islam, M. N. (2026). Smallholder farmers' perceptions of climate-smart practices in oilseed and pulse production: Evidence from Barguna district, Bangladesh. *Archives of Agriculture and Environmental Science*, *11*(2), 168-175, https://dx.doi.org/10.26832/24566632.2026.110203

INTRODUCTION

Agriculture remains the backbone of Bangladesh's rural economy, providing employment, food security, and household income. In coastal areas such as Barguna District, this sector is increasingly threatened by climate-induced stresses, including soil salinity, waterlogging, cyclones, and erratic rainfall, all of which significantly reduce crop productivity and diversification potential (Islam *et al.*, 2021; Swarnokar *et al.*, 2025). Salinity intrusion and extreme weather events have constrained cropping intensity by 20–35%, forcing farmers to leave land fallow during the rabi season and contributing to livelihood insecurity among smallholders (Uddin & Hoque, 2025; Zaman *et al.*, 2024). Consequently, farm incomes in these regions have declined by an estimated 15–30%, increasing dependence on off-farm income and seasonal migration (Jalal *et al.*, 2021). These challenges highlight an urgent need to identify climate-resilient cropping systems that can sustain productivity and improve rural livelihoods.

Within this context, oilseeds and pulses have emerged as promising alternatives to the dominant rice-based cropping systems in coastal Bangladesh (Akber *et al.*, 2022). These crops, including mustard, sesame, sunflower, groundnut, soybean, mung bean, lentil, chickpea, and grass pea, offer multiple agronomic, nutritional, and economic benefits (Badhan *et al.*, 2024). They con-

tribute to dietary diversification, reduce dependence on imported edible oil, enhance soil fertility through biological nitrogen fixation, and provide higher returns compared to fallow land use (Rahman *et al*., 2024; Hasan & Kumar, 2022). In Bangladesh, pulses are primarily cultivated in the Rabi season (80%), Among pulse crops, grass pea occupies the largest share of cultivated land, followed by lentil at 24%, mung bean at 23%, black gram at 7%, cowpea at 7%, chickpea at 1%, and field pea at 1% (Kundu *et al*., 2022; Jamal *et al*., 2022). Despite their benefits, their adoption in coastal areas remains limited. Several oilseed and pulse crops show strong adaptation potential under coastal agro-ecological conditions (Sarma *et al*., 2024; Islam *et al*., 2024). The sunflower performs relatively well under salinity stress with proper soil management, mustard benefits from short-duration varieties and improved fertilization, while sesame and groundnut offer drought tolerance and soil fertility benefits (Badhan & Mousumi, 2020; Haque, 2024; Howlader *et al*., 2025). However, productivity remains constrained by biophysical limitations such as high salinity, poor soil fertility, and seasonal freshwater scarcity, alongside socioeconomic constraints including limited access to quality seed, credit, and extension services (Abdullah *et al*., 2025; Ferdousi *et al*., 2024; Islam *et al*., 2022).

In response to these challenges, farmers in coastal Bangladesh are increasingly adopting climate-smart agriculture (CSA) practices, including crop diversification, adjusted planting calendars, and improved water management (Momin *et al*., 2025). Yet, the effectiveness and scale of these practices depend on farmers' knowledge, attitudes, institutional support, and access to resources (Ashrit & Joshi, 2024). Spatial variability in soil salinity further complicates decision-making, requiring site-specific crop and management strategies (Sarkar *et al*., 2024). While policy interventions such as salt-tolerant crop development, integrated coastal zone management, and infrastructure support exist, implementation gaps and uneven service delivery continue to limit their impact (Bokhtiar *et al*., 2023; Mukherjee *et al*., 2025; Mila *et al*., 2024). Although oilseeds and pulses have been widely recognized for their potential to enhance climate resilience and nutritional security, their adoption in coastal Bangladesh remains low and uneven. Existing studies have primarily focused on agronomic performance and biophysical constraints, with limited attention to farmers' perceptions, decision-making processes, and behavioral determinants of CSA adoption in oilseed and pulse systems (Kabir *et al*., 2024; Kundu *et al*., 2020). In particular, there is a lack of empirical evidence at the smallholder level in Barguna District that integrates farmers' knowledge, attitudes, adoption behavior, and constraints in relation to climate-smart oilseed and pulse cultivation (Pervez *et al*., 2025; Akter *et al*., 2023). Understanding farmers' perceptions and adoption behavior is critical for designing effective interventions that promote climate-resilient agriculture in coastal Bangladesh. Evidence generated from this study can inform targeted extension services, improve technology dissemination, and support policy formulation aimed at strengthening diversified and sustainable farming systems. It also contributes to enhancing food security, nutritional outcomes, and livelihood resilience in vulnerable coastal communities.

This study is novel in its integrated approach that combines household surveys, field observations, and key informant interviews to simultaneously examine farmers' perceptions, adoption behavior, and constraints regarding climate-smart oilseed and pulse production. Unlike previous research that largely emphasizes agronomic or biophysical aspects, this study focuses on the behavioral and institutional dimensions of adoption within a highly climate-vulnerable coastal setting. The study aims to examine farmers' perceptions, adoption patterns, and challenges associated with climate-smart agricultural practices for oilseed and pulse production in Barguna District. By generating empirical evidence at the farm level, the research seeks to support policy and programmatic interventions that enhance climate resilience, promote crop diversification, and strengthen sustainable agricultural systems in coastal Bangladesh.

MATERIALS AND METHODS

Study sites and design

The study was conducted in Barguna District, located in the coastal region of Bangladesh, focusing on Barguna Sadar Upazila. Five unions (Aylapatakata, Badarkhali, Gowrichanna, Kebrabunia, and Phuljhut) were selected. From each union, 24 farming households were surveyed, totaling 120 samples, to assess oilseed and pulse cultivation in climate-vulnerable coastal farming systems. This study employs a mixed-methods research design, combining quantitative and qualitative approaches to address the research objectives comprehensively. The quantitative component collects structured data from farmers cultivating oilseeds and pulses, while the qualitative component gathers insights from representatives of the Department of Agricultural Extension. This dual approach provides a deeper understanding of farmers' experiences, perceptions, and challenges in agricultural practices, ensuring a comprehensive analysis of both practical and institutional perspectives.

Sampling strategy and sample size

A comprehensive sampling strategy was adopted to ensure representativeness and methodological rigor. A complete list of 635 oilseed and pulse farmers was obtained from the Department of Agricultural Extension (DAE), Barguna Sadar Upazila. Using a 95% confidence level and a 5% margin of error, the required sample size was determined to be 120 respondents. Stratified random sampling was applied to ensure proportional representation across six unions, capturing variations in socio-demographic characteristics, landholding size, and farming practices. In addition, four key informant interviews were conducted with Upazila Agriculture Officers and Sub-Assistant Agriculture Officers to obtain in-depth insights into production constraints and institutional support mechanisms.

Survey tools development

This study adopted a participatory approach to develop and finalize data collection tools for both quantitative and qualita-

tive components. Initially, relevant reports, scholarly literature, and peer-reviewed journal articles were reviewed to identify key issues and inform the design of preliminary tools. Draft versions of the structured survey questionnaire and the key informant interview (KII) guide were then developed and shared with subject-matter experts through virtual consultations to solicit feedback. Based on the experts' recommendations, the tools were revised and resubmitted for final validation. Subsequently, a pilot test was conducted with a small group of farmers to assess clarity, consistency, and contextual relevance, ensuring the reliability and effectiveness of the instruments before full-scale data collection.

Data collection and analysis

Data were collected using a mixed-methods approach combining quantitative and qualitative techniques. Primary quantitative data were gathered through structured household surveys administered to 120 selected oilseed and pulse farmers using face-to-face interviews. Qualitative data were obtained through four key informant interviews (KIIs) with Upazila Agriculture Officers and Sub-Assistant Agriculture Officers to capture institutional perspectives and contextual insights. Secondary data were collected from published literature, government reports, and relevant databases. Quantitative data were coded and analyzed using SPSS (version 26) and Microsoft Excel, applying descriptive statistics and inferential analyses where appropriate. Qualitative data were analyzed thematically to identify recurring patterns, challenges, and opportunities related to pulses and oilseed production in the study area.

RESULTS AND DISCUSSION

Socioeconomic and demographic characteristics of farmers

The study surveyed 120 farmers in Barguna district to understand their socioeconomic profile. Male farmers constituted the vast majority of 93.33%, while female farmers represented only 6.67%. Age distribution showed that nearly 48.33% of respondents were aged 18–35 years, followed by 30.83% aged 36–45 years, 13.33% aged 46–59 years, and 7.50% aged 60 years or older, indicating a relatively young farming population (Table 1). Educational attainment was generally low, with 30.83% of farmers having no formal education, 38.33% completing primary education, 19.17% achieving SSC, 9.17% HSC, and only 2.50% holding a BA or BSc degree. Regarding farm size, 35.83% operated less than 1 hectare, 43.33% had 1–2 hectares, and 20.83% cultivated more than 2 hectares. Farming experience varied, with 10.83% farming for less than 5 years, 22.50% for 5–10 years, 39.17% for 10–15 years, and 27.50% exceeding 15 years, reflecting a mix of emerging and experienced farmers. The study provides key insights into the socioeconomic profile and farming practices of oilseed and pulse farmers in coastal Bangladesh. A relatively young farming population indicates potential for adopting climate-resilient and innovative practices. Small farm sizes and landholding patterns reflect the predominance of smallholders, posing challenges for mechanization and large-scale diversification (Rana *et al*., 2024). While experienced farmers facilitate knowledge transfer, younger farmers may be more receptive to innovation (Sunny *et al*., 2022). These findings underscore the need for targeted extension services, capacity-building initiatives, and supportive policies to enhance sustainable oilseed and pulse diversification and climate-resilient agriculture.

Farmer cultivated oilseed & pulse crops in Barguna district

The study revealed that oilseed and pulse cultivation are important components of farming in Barguna District. Among oilseeds, mustard was the most widely cultivated crop, grown by 75.83% of farmers, followed by sesame, sunflower, groundnut, and soybean, which were 45.00%, 37.50%, 31.67% and 26.67%, respectively (Table 2). These figures indicate the dominance of mustard and the emerging interest in other oilseed crops for income generation and nutritional purposes. Pulses were less widely cultivated, with gram grown by 27.50% of farmers, mung bean by 20.00%, and grass pea (Khesari) by 10.83%. The lower adoption of pulses may reflect limited awareness, market access, or perceived cultivation risks. The findings indicate that oilseed cultivation, particularly mustard, dominates crop production in Barguna District, reflecting its adaptability and market demand. Other oilseeds such as sesame, sunflower, groundnut, and soybean show moderate adoption, suggesting emerging interest in diversification. Pulses, including gram, mung bean, and grass pea, are less commonly cultivated, potentially due to limited awareness, market constraints, and perceived agronomic risks (Abraham & Pingali, 2021). Promoting both oilseeds and pulses could enhance nutritional security and climate resilience among smallholder farmers. Targeted extension services, improved market linkages, and access to climate-resilient varieties are essential to support diversified and sustainable farming in coastal Bangladesh (Nahar *et al*., 2025). Overall, the data highlight both the potential and the constraints for diversifying crop production toward oilseeds and pulses in the region.

Farmers perceived production challenges in oilseeds and pulse production

The study identified multiple challenges perceived by farmers in cultivating oilseeds and pulses in Barguna District, highlighting the vulnerability of coastal agriculture to both biophysical and socioeconomic constraints. Among environmental challenges, climate change and extreme weather events were reported by 78.33% of respondents, followed closely by waterlogging and flooding, which were 77.50%, and soil salinity, which was 66.67%, reflecting the significant impact of coastal agro-ecological conditions on crop production (Table 3). Soil fertility decline was noted by 53.33% of farmers, indicating ongoing degradation that may affect long-term productivity. Farmers also reported challenges related to agricultural inputs and services. Limited access to extension services was a concern for 76.67% of respondents, while 67.50% indicated a lack of quality seeds, and 60.83% cited high input costs. Pest and disease infes-

Table 1. Socioeconomic and demographic characteristics of farmers.

Socioeconomic and demographic characteristics	Frequency (N= 120)	Percentage
Sex		
Male	112	93.33%
Female	8	6.67%
Age groups		
18-35 years	58	48.33%
36-45 years	37	30.83%
46-59 years	16	13.33%
60 years and above	9	7.50%
Education levels		
No Education	37	30.83%
Primary	46	38.33%
SSC	23	19.17%
HSC	11	9.17%
BA/BSc	3	2.50%
Farm Size (ha)		
<1 ha	43	35.83%
1-2 ha	52	43.33%
>2 ha	25	20.83%
Farming Experience (years)		
<5 years	13	10.83%
5-10 years	27	22.50%
10-15 years	47	39.17%
> 15 years	33	27.50%

Table 2. Farmer cultivated oilseed & pulse crops in Barguna district.

Crop category	Crop name	Frequency (N= 120)	Percentage
Oilseeds	Mustard	91	75.83%
	Sesame	54	45.00%
	Sunflower	45	37.50%
	Groundnut	38	31.67%
	Soybean	32	26.67%
Pulses	Mung Bean	24	20.00%
	Gram (Lentil, Masur)	33	27.50%
	Grass pea (Khesari)	13	10.83%

Table 3. Farmers perceived production challenges in oilseeds and pulse production.

Challenges	Frequency (N= 120)	Percentage
Soil salinity	80	66.67%
Waterlogging / Flooding	93	77.50%
Climate change and extreme weather events	94	78.33%
Limited extension services	92	76.67%
Soil Fertility Decline	64	53.33%
Lack of quality seeds	81	67.50%
High input costs	73	60.83%
Pest and disease infestation	65	54.17%
Limited irrigation facilities	71	59.17%
Market price volatility	64	53.33%
Unfavorable market access	74	61.67%
Access to credit and financing	64	53.33%
Lack of proper storage facilities	68	56.67%

tations were found in 54.17%, and limited irrigation facilities were 59.17%, further constraining production. Market-related challenges were also prominent, with 61.67% of farmers reporting unfavorable market access, 53.33% citing price volatility, and 53.33% noting limited access to credit and financing. Additionally, 56.67% of respondents identified inadequate storage facilities as a constraint, which may lead to post-harvest losses.

Farmers in Barguna face multiple challenges in oilseed and pulse cultivation, including soil salinity, waterlogging, climate extremes, limited extension services, and market access (Mukherjee *et al*., 2025). Addressing these challenges requires integrated interventions, such as climate-resilient pulses and oilseed varieties, improved irrigation, access to quality seeds, extension support, and strengthened market linkages to enhance productivity and livelihoods. Another study found that about 25% of farmers faced no rainfall after sowing; 38% cited high machine costs, 30% lacked modern machinery, 14% lacked deep tube wells, and 10% lacked sweet water (Kumar *et al*., 2023). These findings highlight the need for integrated interventions, including climate-resilient technologies, improved input supply, extension support, and strengthened market linkages to enhance the productivity and profitability of oilseed and pulse cultivation in coastal Bangladesh.

Table 4. Farmers perceived an opportunity for expanding oilseeds and pulses.

Opportunity	Frequency (N= 120)	Percentage
Availability of fallow land	44	36.67%
Adoption of short-duration varieties	98	81.67%
Government support/subsidies	109	90.83%
Growing local & export market demand	31	25.83%
Climate-smart agriculture practices	26	72.50%
Community and cooperative farming	93	77.50%
Diversification of livelihoods	59	49.17%
Agro-processing and value addition	75	62.50%
Diversified crop rotation systems	53	44.17%

Table 5. Adoption of climate-resilient practices in oilseeds and pulse production.

Climate-resilient Practice	Frequency (N= 120)	Percentage
Saline-tolerant crop varieties	41	34.17%
Crop rotation/intercropping	65	54.17%
Timely planting to avoid floods	59	49.17%
Improved drainage/raised beds	80	66.67%
Integrated pest management (IPM)	28	23.33%
Water-efficient irrigation systems	34	28.33%
Soil conservation techniques	37	30.83%
Use of organic fertilizers	52	43.33%
Early warning systems for weather	46	38.33%
Use of biodegradable pesticides	32	26.67%
Soil fertility management	35	29.17%
Climate-Smart/precision farming	34	28.33%

Farmers perceived an opportunity for expanding oilseeds and pulses

Farmers in Barguna perceived multiple opportunities for expanding oilseed and pulse cultivation, supported by both policy initiatives and farm-level adaptation strategies. Government support and subsidies were identified by 90.83% of farmers, highlighting the importance of public incentives and input assistance (Table 4). Adoption of short-duration varieties was recognized by 81.67% of respondents. 77.50% perceived community and cooperative farming as an opportunity. Agro-processing and value addition were noted by 62.50% of respondents, and livelihood diversification was viewed as an opportunity by 49.17% of farmers, while 44.17% highlighted diversified crop rotation systems for improving soil health and reducing risk. 36.67% farmers reported the availability of fallow land use potential. However, climate-smart agriculture practices adaptation opportunities were reported by 72.50% of farmers, indicating gaps in awareness of climate-resilient practices.

The perceived opportunities highlight multiple pathways to strengthen oilseed and pulse systems in coastal Bangladesh. High adoption of short-duration varieties and utilization of fallow land can enhance cropping intensity and productivity (Kassa *et al*., 2022). Government support and integrated farming improve access to inputs, markets, and services, while agro-processing increases value and income. Climate-smart practices are currently recognized by promoting resilient varieties and CSA techniques that improve yields and soil health (Hoque *et al*., 2022). Growing local and export demand emphasizes the need for market development and diversified crop rotation systems to sustain production and profitability (Mila *et al*., 2024). Overall, the findings suggest that strengthening policy support, promoting suitable crop varieties, enhancing farmer organizations, extension services, and value chains development are essential to unlocking the full potential of oilseeds and pulses to enhance productivity, profitability, and livelihood resilience in coastal Bangladesh.

Adoption of climate-resilient practices in oilseeds and pulse production

The study revealed that the improved drainage systems and raised beds were the most widely adopted practices, reported by 66.67% of farmers, reflecting the need to address waterlogging and flood risks in coastal areas. Crop rotation and intercropping were practiced by 54.17%, while timely planting to avoid floods was adopted by 49.17% of respondents. The use of organic fertilizers was reported by 43.33%, supporting soil health improvement, whereas early warning systems for weather events were used by 38.33% of farmers (Table 5). While adoption of saline-tolerant varieties and soil conservation techniques remained moderate, at 34.17% and 30.83% respectively, soil fertility management practices were reported by 29.17% of respondents. Water-efficient irrigation systems and climate-smart farming technologies were adopted by 28.33% of farmers, and biodegradable pesticides were used by 26.67%. Integrated pest management showed the lowest adoption rate at 23.33%, highlighting constraints rated to knowledge, input availability, and technical capacity. The recent study shows that farmers in coastal Bangladesh prioritize practical climate-resilient measures such as improved drainage, raised beds, crop rotation, and timely planting, similar to climate-smart agriculture tech-

nologies adoption patterns, where about 57.91% of coastal farmers (Mia & Roy, 2025), to cope with waterlogging and climate variability. Moderate adoption of 65% of saline-tolerant varieties and soil management practices indicates growing awareness but limited access to technologies, a pattern noted in coastal CSA research (Majumder *et al*., 2024). Low uptake of IPM, precision farming, and water-efficient irrigation reflects constraints in knowledge, cost, and extension support (Haque *et al*., 2021). Overall, the findings suggest that while farmers prioritize structural and agronomic adaptations, greater extension support and access to technologies are needed to scale up comprehensive climate-smart practices in oilseed and pulse production in Barguna.

Limitations

Data collection relied on self-reported information, which may be subject to recall and social desirability bias. The study was conducted in a single Upazila of Barguna district, limiting the generalizability of the findings to other coastal regions of Bangladesh. Additionally, time, resource, and accessibility constraints restricted the sample size and the inclusion of remote island communities.

Recommendations

Expand field-based training and demonstrations to strengthen farmers' knowledge of oilseed and pulse production, emphasizing climate-smart practices, integrated pest management, and saline-tolerant varieties.

- Ensure timely and affordable access to quality seeds, fertilizers, and pest management inputs through public–private partnerships.
- Improve market access by strengthening storage, processing, value addition, and financial services to reduce price volatility and post-harvest losses.
- Prioritize oilseed and pulse development in coastal areas through supportive policies, targeted subsidies, and promotion of cooperative farming and fallow land use aligned with climate adaptation strategies.

Conclusion

This study examined farmers' socioeconomic characteristics, production patterns, perceived challenges, opportunities, and adoption of climate-resilient practices in oilseed and pulse cultivation in Barguna district, coastal Bangladesh. The findings indicate that farming in the study area is predominantly male-dominated, with a relatively young but moderately experienced farmer population and generally low educational attainment. Mustard emerged as the most widely cultivated oilseed, while pulse cultivation remains comparatively limited, suggesting an ongoing dependence on a narrow crop portfolio. The study identified multiple and interlinked constraints affecting production, including severe climate-related stressors such as salinity, waterlogging, and extreme weather events, alongside institutional and market-related challenges like limited access to extension services, quality seeds, credit, and stable market prices. Despite these barriers, farmers recognized significant opportunities for expanding oilseed and pulse production, particularly through government support, short-duration varieties, and cooperative farming approaches. Adoption of climate-resilient practices was moderate, with improved drainage systems and raised beds being the most widely implemented strategies, while more advanced practices such as integrated pest management and climate-smart technologies remained low. Overall, the results highlight a clear gap between awareness and effective adoption of climate-smart agricultural practices. Strengthening extension services, improving access to inputs and finance, and promoting context-specific climate-resilient technologies are essential to enhance productivity, resilience, and sustainability of oilseed and pulse-based farming systems in coastal Bangladesh.

ACKNOWLEDGEMENTS

The author would like to express his wholehearted respect, sincere appreciation, and profound indebtedness to Professor Dr. Md. Abdullahil Baque, Chairman of the Department of Agronomy, Sher-e-Bangla Agricultural University (SAU), for his overall guidance in designing and implementing this study and finalizing the report. The author is also grateful to Md. Nasfiqul Islam, who served as a research assistant for this study and played a vital role in data collection, key informant interviews, overall study implementation, data analysis, and report preparation. We acknowledge the free version of ChatGPT, an artificial intelligence tool for grammar correction and language refinement.

DECLARATIONS

Author contribution statement: Conceptualization: M.A.I. and M.N.I.; Methodology: M.A.I.; Software and validation: M.N.I.; Formal analysis and investigation: M.N.I.; Resources: M.A.I.; Data curation: M.N.I.; Writing original draft preparation: M.A.I.; Writing—review and editing: M.A.I.; Visualization: M.A.I. and M.N.I.; Supervision: M.A.I.; Project administration: M.A.I.; Funding acquisition: M.A.I. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

Ethics approval: This study was conducted in view of the institutional ethical guidelines and does not harm the human participants.

Consent for publication: All co-authors gave their consent to publish this paper in AAES.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

Supplementary data: No supplementary data is available for the paper.

Funding statement: No external funding was received for this study.

Additional information: No additional information is available for this paper.

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